Figure 6 compares the different unblocking techniques in terms of mean access delay for different loads. We note that unblocking techniques 1-3 give lower access delay for higher offer loads than Method 4.

## 5 Conclusion

This paper focuses on the first transmission rule or channel unblocking. We compare techniques for controlling the admittance of new packets into the system in terms of collision multiplicity and mean access delay. Simulation results show that collision multiplicity and access delay values can be reduced for higher loads using the range control parameter $R$ computed at the headend. Also, we show there may be several techniques to compute $R$ and most help improve MAC performance.

## Appendix

The MAC model described in section 2 was implemented using the network simulation tool OPNET [1]. Simulation parameters are set as follows. The network consists of 200 stations evenly spaced, and located at a distance from the headend between 25 km and 200 km. The upstream and downstream propagation delays are set to $5\mu$ s/km. The data rate used is 3 Mbits/s. The size of the data slot is set to 64 bytes, while the size of the minislot is set to 16 bytes, so that 4 CS can fit in a DS. CS are grouped at the beginning of the frame. The frame size is adjusted to 3.072 ms in order to fit up to a maximum of 18 DS (or 72 CS). The maximum request size is set to 32. The traffic type used is defined as follows. Messages are 48-bytes long and are generated according to a Poisson distribution with a mean arrival rate of $\lambda$, where $\lambda$ varies according to the traffic load.

## References


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[1] OPNET is a trademark of MIL3

As anticipated the collision multiplicity is worse as the load increases up to 75% (Figure 1-4). Method 1 is the most effective in reducing the tail of the collision multiplicity distribution.

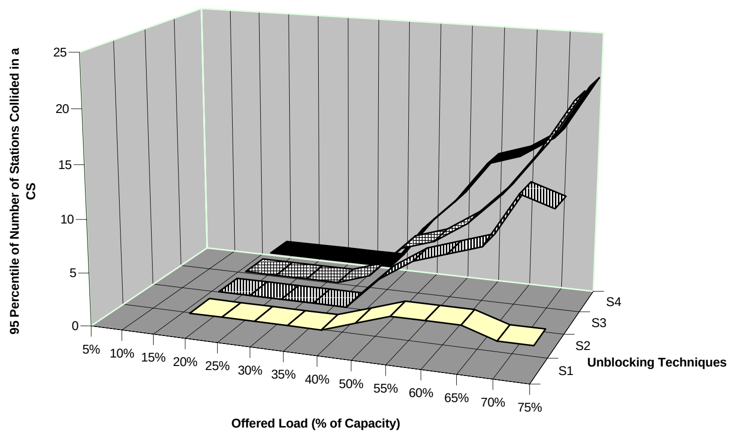


Figure 5: 95 Percentile Collision Multiplicity

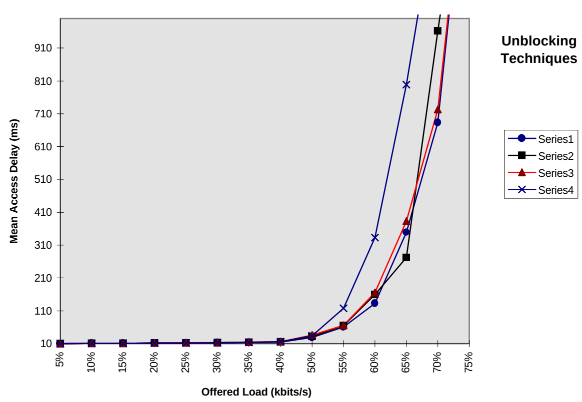


Figure 6: Mean Access Delay vs Offered Load

We note that the maximum number of stations collided in a slot in Figure 1-4, for Method 1 is 13. Method 4 has the worst results with collision multiplicity values up to 110 (Figure 3). Collision multiplicity results are summarized in Figure 5, where we plot the 95 percentile of the collision multiplicity for different load percentages. Method 1 gives better results than Method 2, 3, and 4 in this order. However, it is important to observe from this measurement, that the number of stations involved in a collision is always kept between 5-21. Thus the gain in collision multiplicity may not justify the added complexity as we go from Method 4, to 1.

at the 40%-75% offered load range, since this is the most significant range for collision measurements. Outside this range, there are very few collisions (due to either underloaded or overloaded network conditions). Note that collisions drop in overloaded channels because stations are able to request for multiple packets.

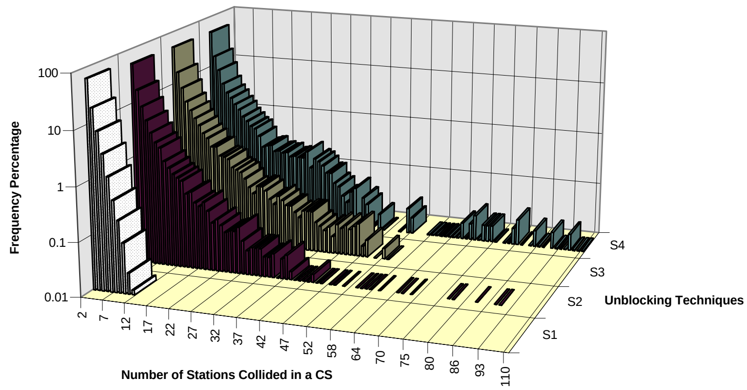


Figure 3: Collision Multiplicity Histogram; Load=65% Capacity

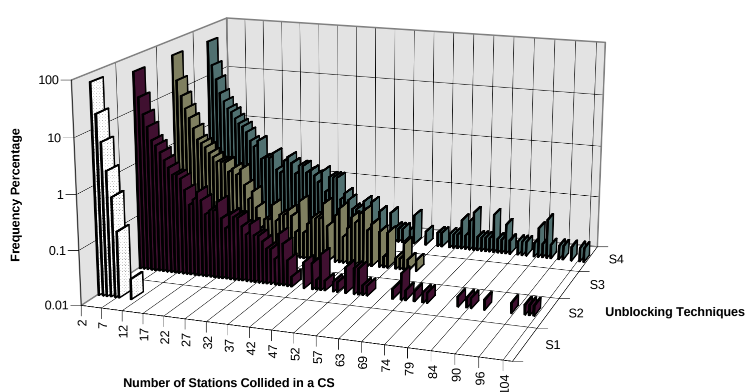


Figure 4: Collision Multiplicity Histogram; Load=75% Capacity

**Method 3** is simply:

$$R(j+1) = max\{3, MS(j+1)\} \tag{3}$$

while **Method 4** sets $R$ to the number of available contention slots in the frame:

$$R(j+1) = MS(j+1) \tag{4}$$

# 4 Results

The four different unblocking techniques presented in the previous section are implemented in the headend module and simulation results using the MAC model described in section 2 are obtained.

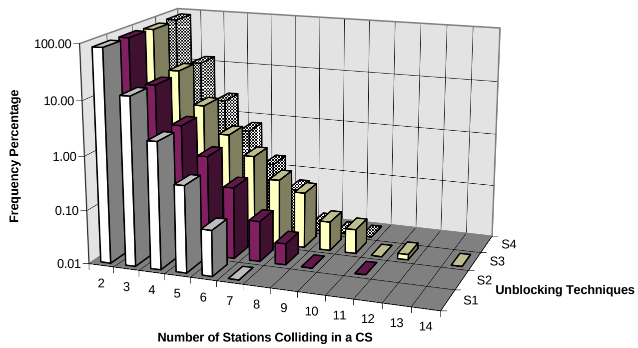


Figure 1: Collision Multiplicity Histogram, Load=40% Capacity

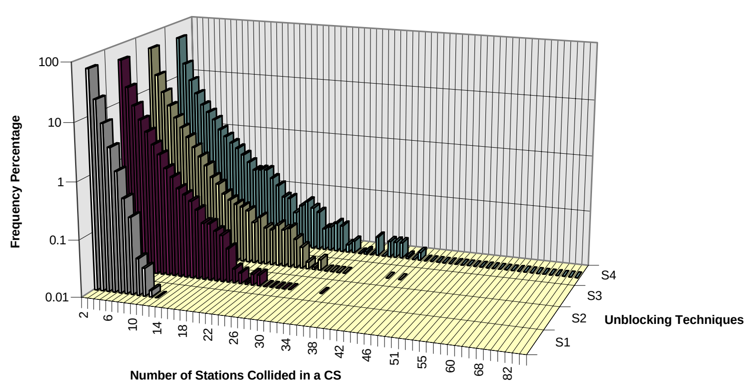


Figure 2: Collision Multiplicity Histogram, Load=55% Capacity

Figure 1-4, show the collision multiplicity frequency (as a percentage of the whole collision sample) for different offered loads (represented as percentages of the total upstream channel capacity). We look

## 2 MAC Model

We design a generic MAC model in order to study different unblocking techniques for new packet arrivals. We briefly describe some of the assumptions used in the experimental work. The simulation parameters including traffic types and test scenarios are given in the appendix.

The upstream frames are divided into a sequence of Contention Slots (CS) and Data Slots (DS). Data traffic is carried via ATM cells. Data packets generated at the stations are segmented into 48-byte chunks and encapsulated in 53-byte ATM cells. Each DS can carry one ATM cell. CSs are used for bandwidth request in contention mode. The size of the CS and DS is chosen so that an integer number of CSs is accommodated in a DS. The ratio of CS/DS is variable from one frame to another by a mechanism implemented at the headend. In our tests, this ratio is varied according to an estimated collision factor and the number of DS requests queued at the headend.

The basic MAC operation is as follows. When a station has data to transmit, it waits at least until the beginning of the next upstream frame in order to send a request in a CS. Then, the station waits for feedback information about collision status and allocation of DS contained in downstream control messages. In our experiments, we assume that the downstream carries feedback information from the headend to the stations with no transmission delay and no bandwidth limitations. In case of collision, the station implements the ternary-tree blocking algorithm to resolve it. Otherwise, the station is granted a DS sometime in the future to send its data.

## 3 Newcomers Unblocking Techniques

The principle of the ternary-tree contention resolution [1, 2, 3, 4] algorithm, is that when a collision occurs, all the stations involved in this collision split into 3 subsets, each randomly selecting a number between 1 and 3. The basic idea is to allow different subsets to resolve their collisions sequentially. Thus, for each collided slot in frame $j$, 3 slots are reserved for stations retransmissions in frame $(j+1)$. If the frame contains less contention slots than needed for resolving collisions, the groups of stations corresponding to the unavailable contention slots wait until additional slots become available. Similarly, stations transmitting requests for the first time (or newcomers), wait until contention slots become available in a frame. Only those contention slots that are not reserved for collision resolution are open for newcomers. This feature of the ternary-tree algorithm is called "blocking".

A careful review of the ternary-tree blocking mechanism reveals that while collisions are resolved quickly [5] (relatively low mean access delay and delay variance), a rather large number of newcomers may send requests simultaneously once all previous collisions have been resolved and the channel open for new contentions or "unblocked". This causes the collision multiplicity factor to increase significantly especially for high load situations leading to undesired laser clipping effects [6].

In order to correct this behavior, a parameter $R$, computed at the headend, is introduced to control first transmissions or channel unblocking [7, 8]. $R$ is the range over which each station can randomly select a slot for contention. If the random number chosen is greater than the total number of contention slots available for newcomers, the station has to repeat this process next cycle time. Otherwise the station sends its request in the selected contention slot number. Here, we examine four techniques for computing $R$ with various degrees of complexity.

**Method 1** [7] consists of the following:

$$R(j+1) = max\{min[n,\ R(j) - MS(j) + col(j) * \frac{(e-1)}{(e-2)} + \frac{MS(j)}{e}],\ MS(j+1)\} \tag{1}$$

where $n$ is the number of stations, $MS(j)$ is the number of contention minislots in the $j$th frame, and $col(j)$ is the number of collided minislots in the $j$th frame.

**Method 2** computes $R$ according to:

$$R(j+1) = min\{max[MS(j+1),\ \alpha * RQ(j+1)],\ n\} \tag{2}$$

where $RQ$ is the length of the request queue at the headend, and $\alpha = 1.9$.

# New Packet Admittance Policies for IEEE 802.14 MAC Protocol

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**Abstract**

*The main functionality of a Medium Access Control (MAC) layer protocol for a bidirectional Cable TV network using a Hybrid Fiber Coaxial (HFC) technology, is to control the access of the various nodes on to the shared medium. Currently, MAC specifications are being drafted by the IEEE 802.14 (Cable TV) working group.*

*The goal of this paper is to examine given the ternary-tree blocking algorithm for resolving collisions, policies enforced by the headend for admitting new traffic on the shared medium. We evaluate different techniques for "unblocking" new backlogged traffic after collisions are resolved. Performance is measured in terms of the mean access delay and the packet collision multiplicity. Simulation results for configurations of interest are also presented.*

## 1 Introduction

The emergence of the Hybrid Fiber Coaxial (HFC) technology has a significant impact on already deployed Cable TV networks. As more bandwidth becomes available, cable network operators are able to add new services such as video on demand, interactive computer games and video telephony to television broadcast. In order to allow various nodes to share resources in a multiaccess environment, new standards, namely a Medium Access Control (MAC) layer layer protocol, are needed. The MAC protocol is implemented at the root (or headend) and at each of the cable network nodes (or stations) in order to control the upstream (from the stations to the headend) and the downstream (from the headend to the stations) transmissions. The IEEE 802.14 working group has been formed to develop MAC specifications for HFC networks.

So far the group has agreed on various MAC defining characteristics such as, frame format, station addressing, timing and synchronization procedures, and the ternary-tree mechanism to resolve collisions resulting from two or more stations transmitting at the same time. Before the group's activities are over, it is expected that the standard include a complete behavioral description for the station along with the details on the type and contents of the messages exchanged between the headend and the station. While most of the headend functionality with respect to the station will also be fully defined, details in the headend unit on how to allocate bandwidth, grant station's requests, and block new packets from entering the network will be implementation dependent.

In this paper we focus on the issue of admitting new packets in the system given the ternary-tree blocking algorithm for resolving collisions. Our goal is to study the effect of different unblocking techniques on the MAC performance, and more specifically on the number of stations colliding in the same slot or collision multiplicity.

The rest of the paper is structured as follows. Section 2 presents the MAC model used in the simulations. Sections 3 and 4 describe the rules for unblocking newcomers and the experimental results respectively. A conclusion is offered in Section 5. Simulation assumptions and parameters are given in the appendix.